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Tanaka

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(54) **LIGHT SOURCE UNIT AND PROJECTOR**

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G03B 21/14 (2006.01)
G03B 21/20 (2006.01)

(52) **U.S. Cl.**
CPC ***G03B 21/16*** (2013.01); ***G03B 21/145*** (2013.01); ***G03B 21/2026*** (2013.01)

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USPC 353/57, 60–61, 119; 362/294, 373
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,418,586	A *	5/1995	Fujimori et al.	353/122
8,083,357	B2 *	12/2011	Fukui et al.	353/58
2006/0170881	A1 *	8/2006	Seki	G03B 21/10 353/85
2006/0209544	A1	9/2006	Nishikawa et al.	
2008/0117389	A1 *	5/2008	Hamada	G03B 21/16 353/119
2010/0026966	A1 *	2/2010	Nakano	353/61
2011/0188008	A1 *	8/2011	Maeda	G03B 21/28 353/85

FOREIGN PATENT DOCUMENTS

JP	2006-259027	A	9/2006
JP	2008-091052	A	4/2008
JP	2008-176199	A	7/2008

* cited by examiner

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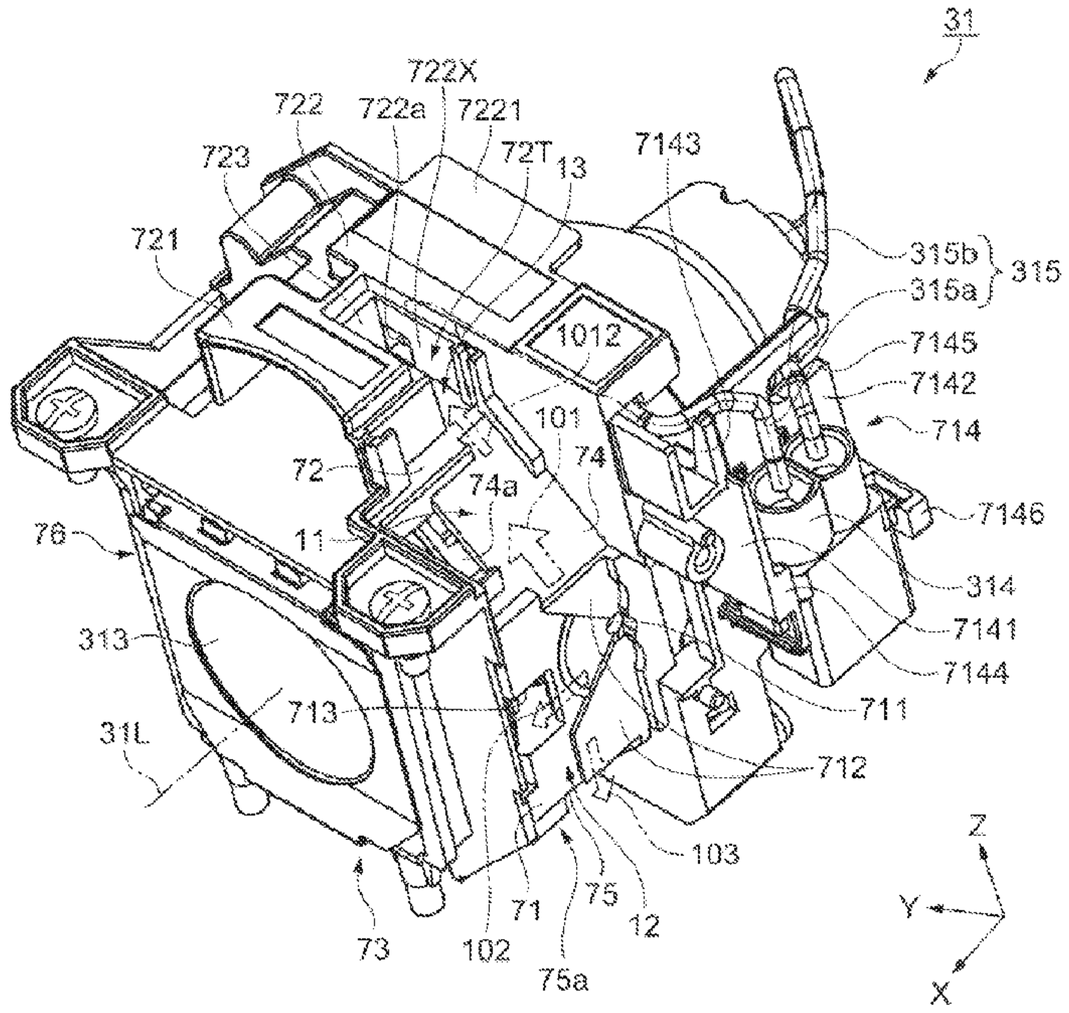
(57) **ABSTRACT**

A light source unit includes a light source, a connecting conductor configured to supply power to the light source, a light source housing configured to accommodate the light source and the connecting conductor. At least part of the connecting conductor is provided on a gripping portion side of the light source housing, and the light source housing includes a lid-side forming portion configured to cover the gripping portion side of the light source and the connecting conductor, and a flow channel configured to guide cooling air to a cover portion of the lid-side forming portion.

6 Claims, 8 Drawing Sheets



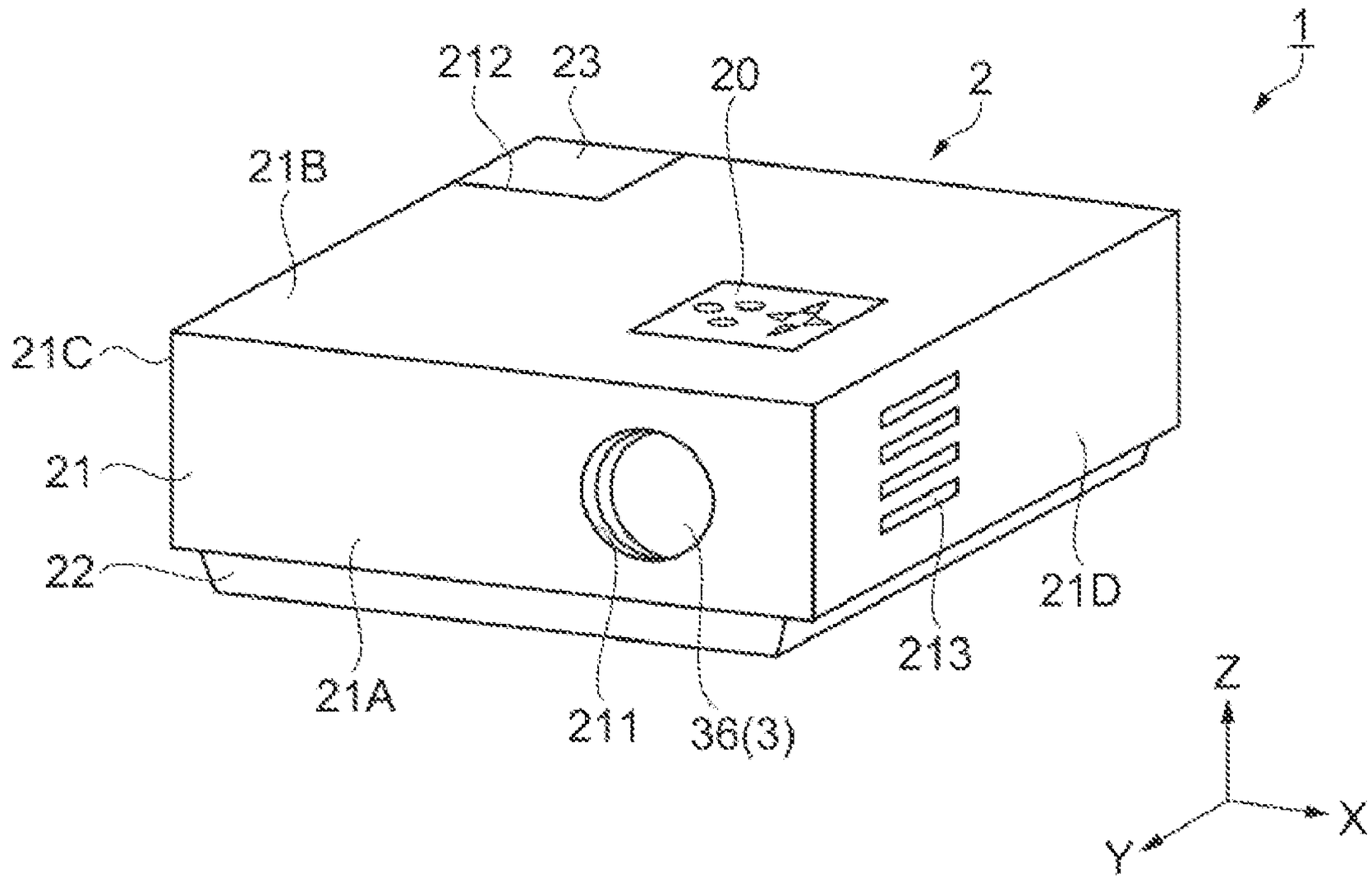
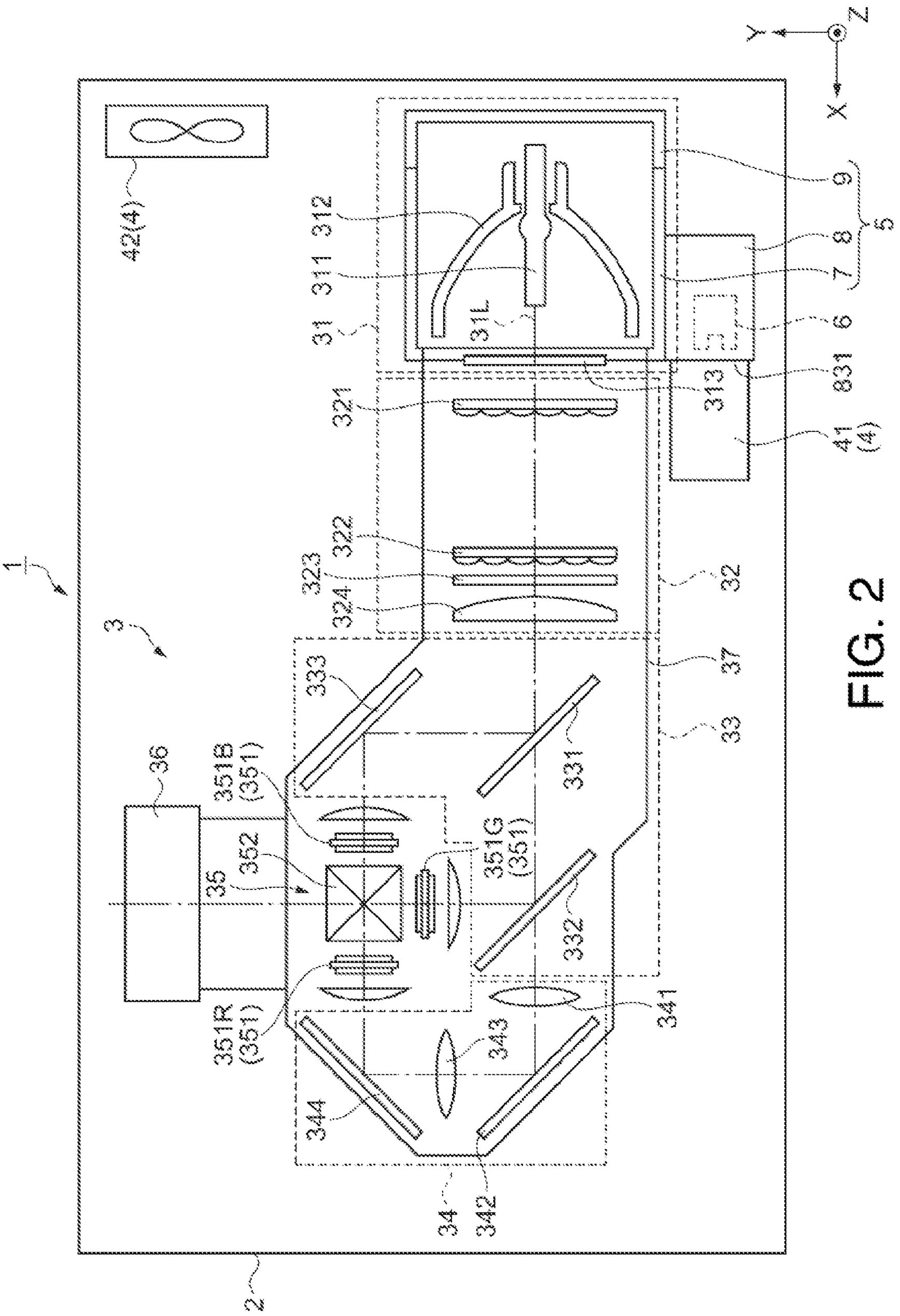


FIG. 1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35
351G
(351)
351R
(351)
343
341
344
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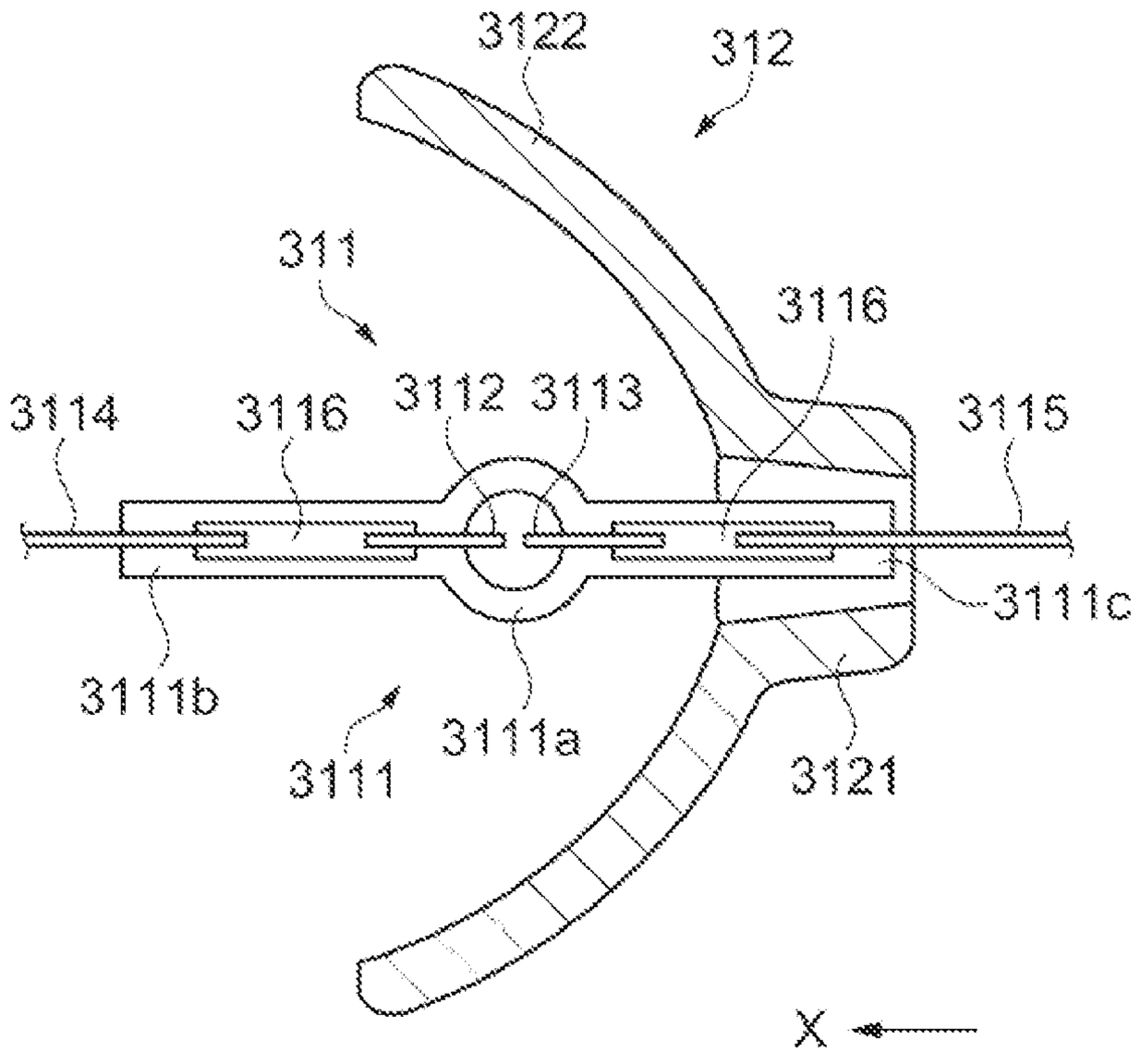
831
41
(4)
32
37
33

FIG. 2


3122
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311
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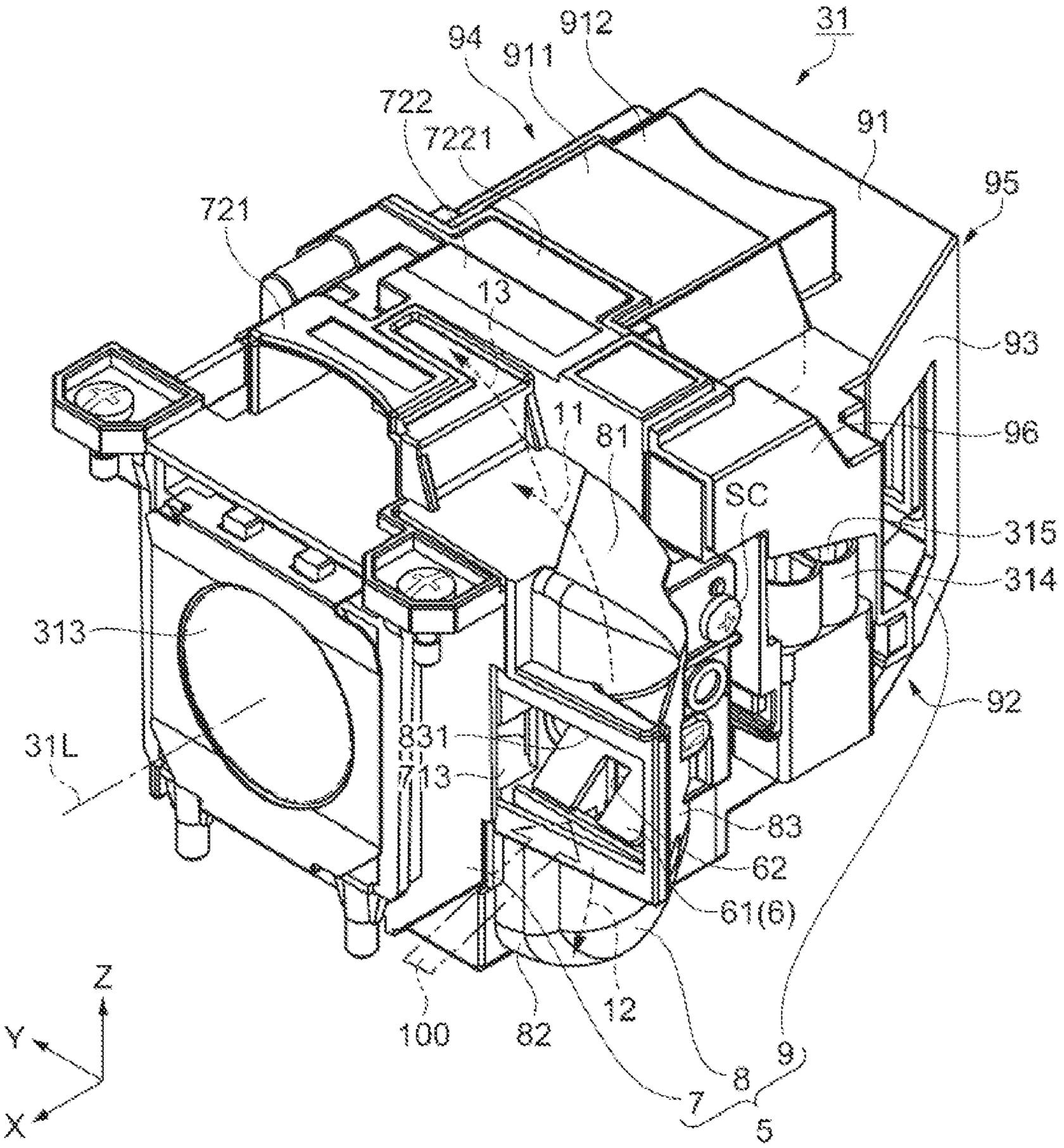
3116
3112
3113
3115
3111c
3111b
3111
3111a
3121
X

FIG. 3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722
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721
13
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313
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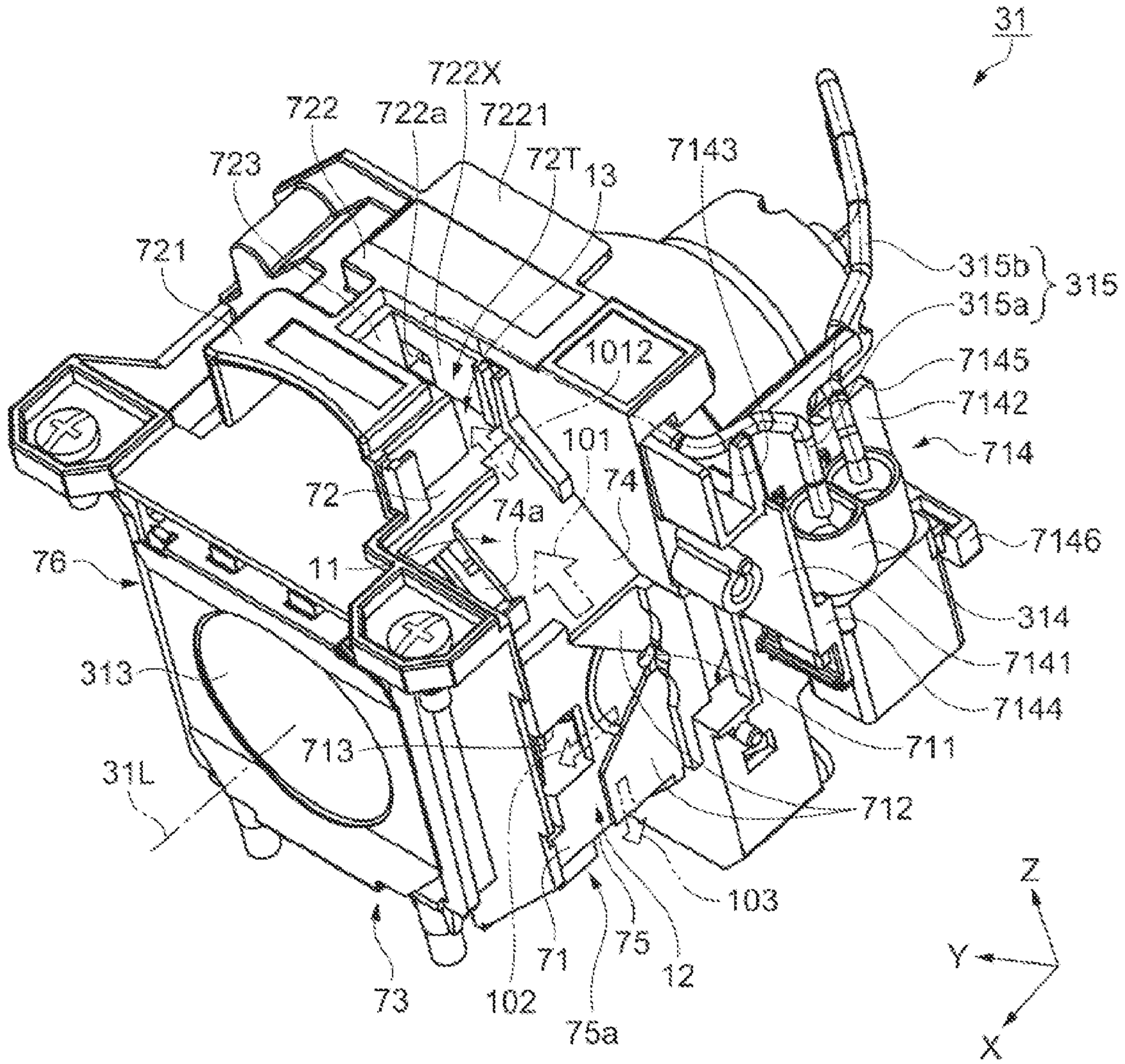
13
83
62
61(6)
12
100
82
9
8
7
5
Z
Y
X

FIG. 4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722X
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72T
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315a
1012
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101
714
74
72
74a
7146
76
11
314
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711
31L
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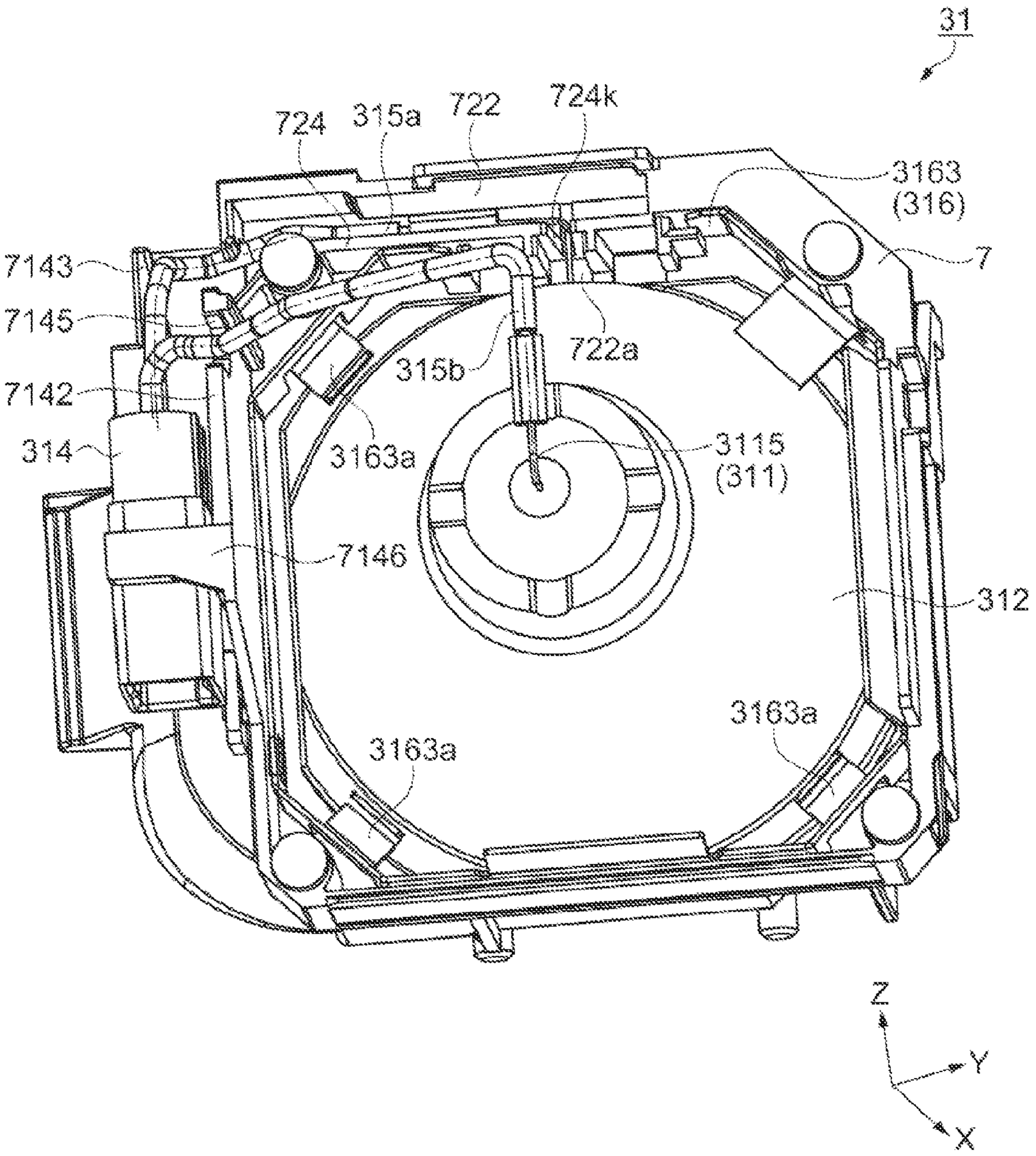
103
Z
Y
X
73
102
71
75
12
75a

FIG. 5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(316)
7
7143
7145
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314
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722a
3163a
3115
(311)
7146
312
3163a
3163a
Z
Y
X

FIG. 6

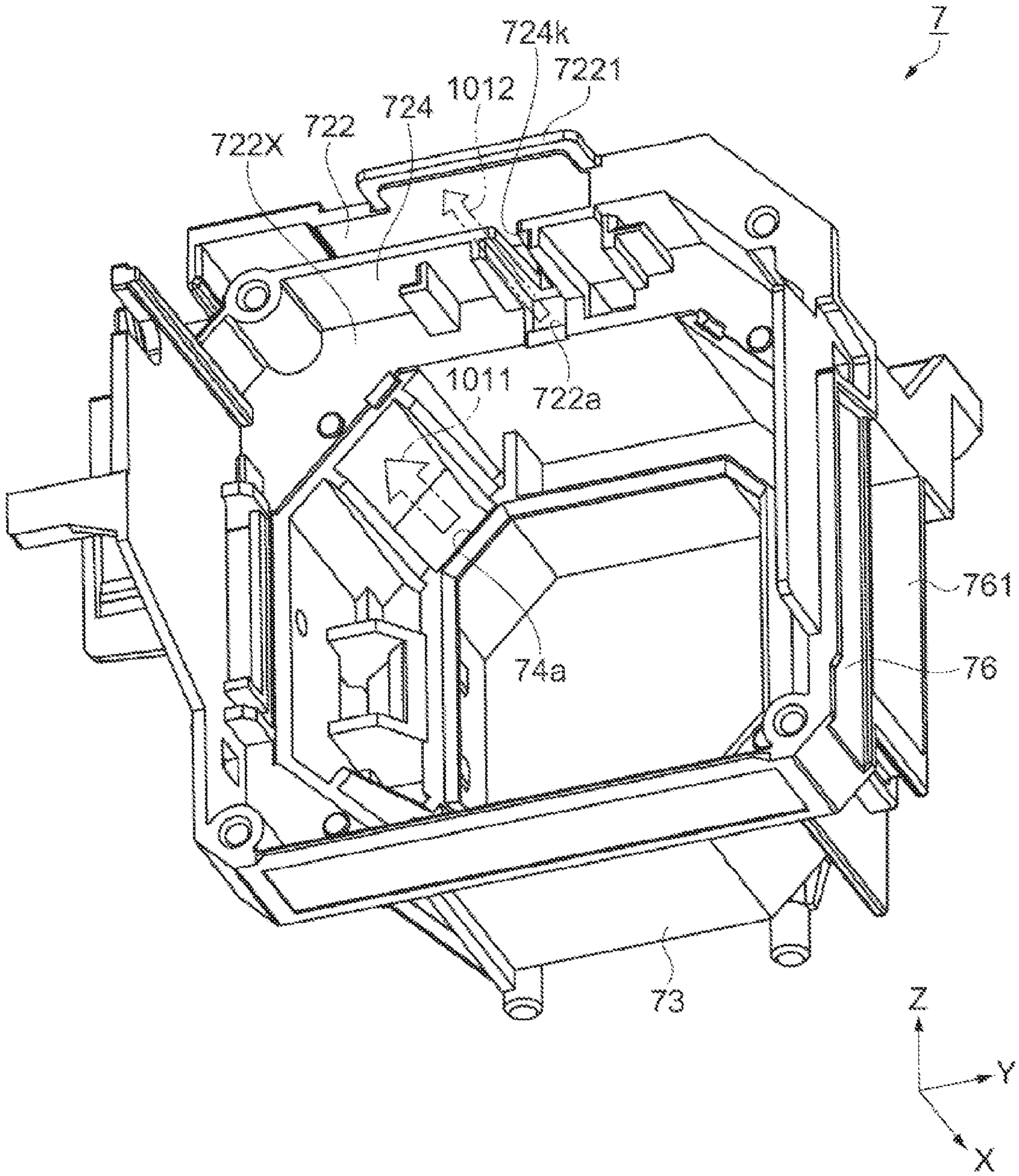
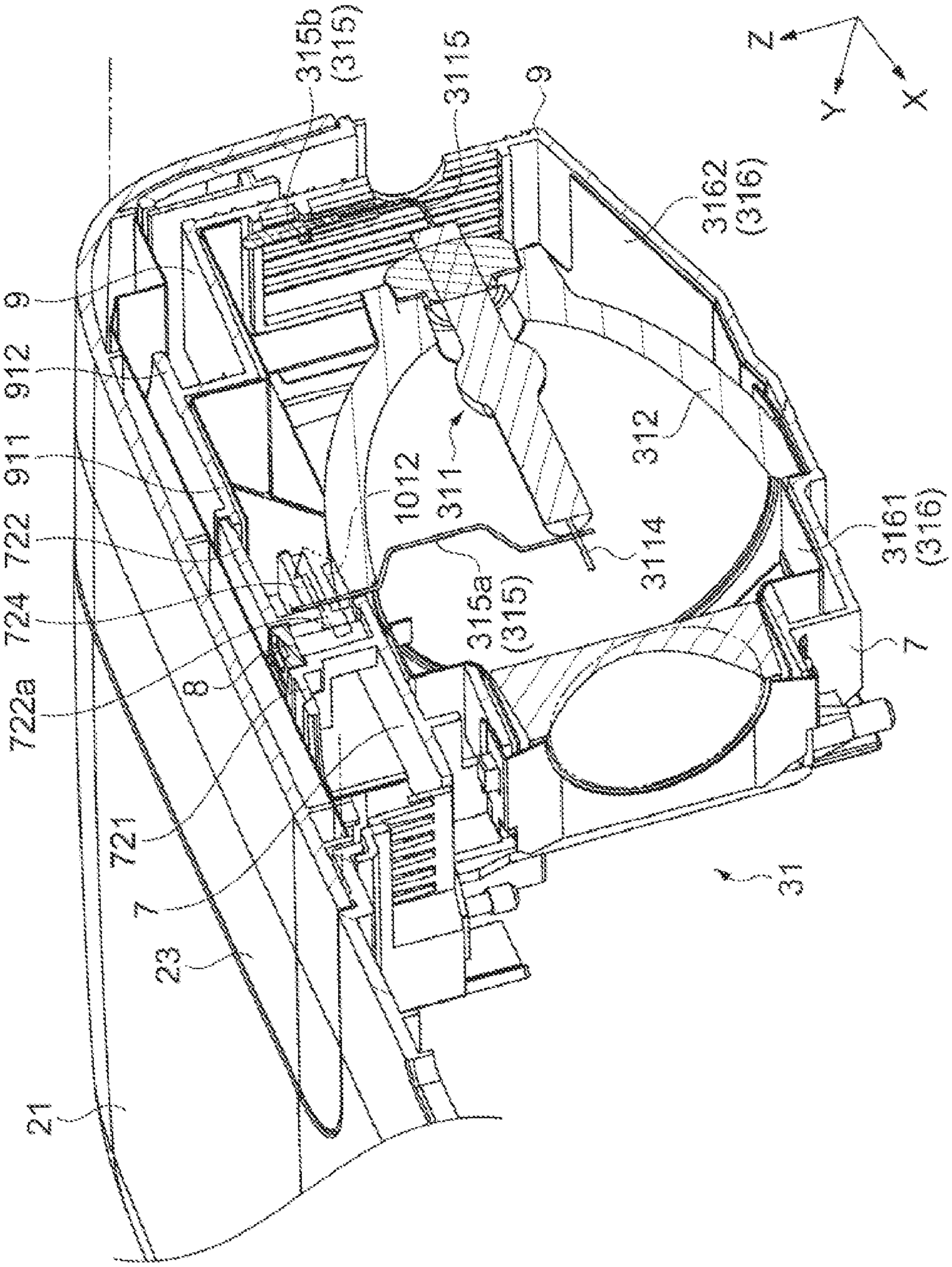


FIG. 7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(315)
31115
9
Z
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(316)
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912
911
724
722
722a
8
721
7
23
21
1012
311
312
3114
315a
(315)
3161
(316)
7
31

FIG. 8

LIGHT SOURCE UNIT AND PROJECTOR

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to Japanese Patent Application No. 2013-063560 filed on Mar. 26, 2013, the entire contents of which are incorporated by reference herein.

BACKGROUND

1. Technical Field

The present invention relates to a projector.

2. Related Art

In the related art, a projector configured to modulate light emitted from a light source unit in accordance with image information and project the modulated light onto a projection surface such as a screen is known. In the light source unit, a discharging type light source such as an extra high pressure mercury lamp is employed in many cases, and the light source unit is configured to be demountably mountable (see JP-A-2008-176199).

The light source unit described in JP-A-2008-176199 includes a light-source lamp, a reflector, a housing configured to accommodate these members in the interior thereof, and a spring member. The reflector is supported and fixed to the housing by using the spring member. The housing is provided with a grip which is configured to be griped by a user, and the grip is gripped for mounting and demounting the light source unit on and from the projector.

JP-A-2008-176199 discloses a drawing in which the spring member is arranged in an exposed manner on the side where the grip of the light source unit is formed. Although the material of the spring member is not described in JP-A-2008-176199, it is considered to be a metal in order to secure the strength required for fixing the reflector to the housing. Although it is not described in JP-A-2008-176199, it is considered that a connecting conductor for supplying power to the light source lamp is laid at a position sufficiently away from the spring member considering a case where the user touches the spring member when mounting and demounting the light source unit.

However, in the light source unit described in JP-A-2008-176199, in order to lay the connecting conductor away from the spring member, assembly could become complex, and an excessive load could be applied to the connecting conductor when being bent at a sharp angle for wiring to a connecting portion to be connected to a power source unit.

SUMMARY

An advantage of some aspects of the invention is to solve at least a part of the problems described above, and the invention can be implemented as the following forms or application examples.

Application Example 1

This application example is directed to a light source unit including a light source configured to emit light; a connecting conductor configured to supply power to the light source; and a light source housing configured to accommodate the light source and the connecting conductor, and including a gripping portion, wherein at least part of the connecting conductor is provided on the gripping portion side of the light source housing, and the light source housing includes: a lid-side forming portion configured to cover the light source and the gripping portion side of the connecting conductor, and a flow channel configured to introduce cooling air to at least part of the lid-side forming portion.

In this configuration, the light source housing is provided with the lid-side forming portion configured to cover the light source and the gripping portion side of the connecting conductor. Accordingly, even when the connecting conductor and a conductive member positioned in the vicinity of the connecting conductor (for example, the member configured to fix the light source to the light source housing or the member configured to block the light from the light source) are arranged so as to be positioned on the gripping portion side with respect to the light source, the lid-side forming portion covers these members. Therefore, a user is prevented from touching or coming close to these members when replacing the light source unit.

Since the light source housing is provided with the flow channel configured to guide the cooling air to at least part of the lid-side forming portion, the lid-side forming portion that is increased in temperature may be cooled down by covering the gripping portion side of the light source.

Therefore, the light source, the connecting conductor, and the conductive member are reliably kept away from the user when the user mounts and demounts the light source unit, whereby deterioration of the light source housing due to the temperature may be suppressed while enhancing wiring flexibility of the connecting conductors and the flexibility in shape of the conductive member. Therefore, the light source unit which has a longer lifetime while achieving easiness of manufacture and improvement of design flexibility is provided.

Application Example 2

In the light source unit of the application example described above, it is preferable that the light source housing includes: an outflow port configured to allow cooling air flowed through the flow channel to go out toward the lid-side forming portion, on the gripping portion side, and a main flow channel configured to allow the cooling air to flow to the light source, and the flow channel guides part of the cooling air flowing through the main flow channel to the outflow port.

In this configuration, the light source housing is provided with the main flow channel configured to allow the cooling air to flow therethrough to the light source, and the part of the cooling air flowing through the main flow channel is guided by the flow channel and is fed to the lid-side forming portion from the outflow port. Accordingly, since an area through which the cooling air is caused to flow may be increased in comparison with a case where the flow channel and the main flow channel are formed individually, efficient cooling of an object to be cooled is achieved.

Application Example 3

In the light source unit of the application example described above, it is preferable that the light source unit includes a reflector configured to reflect light emitted from the light source, and the light source includes a light-emitting tube having a pair of electrodes and a pair of lead wires configured to be electrically connected to the pair of electrodes, one of the pair of lead wires is arranged on a side of the reflector where the light is reflected, the connecting conductor includes a first connecting conductor to be connected to the one of the lead wires and a second connecting conductor to be connected to the other lead wire, and part of

the first connecting conductor is arranged at a position where the cooling air flowing out from the outflow port of the light source housing passes.

In this configuration, since the one of the lead wires is arranged on the side of the reflector where the light is reflected, the first connecting conductor connected to the lead wire is increased in temperature. However, the part of the first connecting conductor is arranged at the position where the cooling air flowed out from the outflow port passes, and hence is cooled by the cooling air fed to the lid-side forming portion. Therefore, the light source unit provided with the light-emitting tube having the pair of electrodes is effectively cooled.

Application Example 4

In the light source unit of the application example described above, it is preferable that the light source housing includes a guide portion configured to position the connecting conductor in cooperation with the lid-side forming portion.

In this configuration, since the light source housing is provided with the guide portion configured to position the connecting conductor in cooperation with the lid-side forming portion, the connecting conductor is reliably laid at a predetermined position on the gripping portion side of the light source. Therefore, further stable cooling of the connecting conductor by the cooling air fed to the lid-side forming portion and reduction of the load applied to the connecting conductor during the step of manufacturing the light source unit and when handling the light source unit are achieved.

Application Example 5

This application example is directed to a projector including the light source unit described above, an external housing configured to accommodate the light source unit and having an opening through which the light source unit is mounted and demounted; and a lid member configured to close the opening.

In this configuration, the same advantages as the light source unit described above are achieved. In particular, in a position in which the projector provided with the light source unit according to Application Example 1 is installed, in the configuration in which the lid member is positioned above the light source unit, the lid-side forming portion is positioned above the light source, so that more remarkable advantages are achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the accompanying drawings wherein like numbers reference like elements.

FIG. **1** is a perspective view schematically illustrating an appearance of a projector of an embodiment.

FIG. **2** is a diagrammatic drawing illustrating a schematic configuration of the projector of the embodiment.

FIG. **3** is a cross-sectional view of a light source and a reflector of the embodiment.

FIG. **4** is a perspective view of a light source unit of the embodiment.

FIG. **5** is a perspective view of the light source unit of the embodiment in a state in which a second housing and a third housing are demounted.

FIG. **6** is a perspective view of the light source unit of the embodiment in a state in which the second housing and the third housing are demounted.

FIG. **7** is a perspective view of a first housing of the embodiment viewed from a −X side.

FIG. **8** is a cross-sectional view of the light source unit and a lid member of the embodiment.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

Referring now to the drawings, a projector according to an embodiment will be described.

The projector of the embodiment is configured to modulate light emitted from a light source in accordance with image information and project the modulated light on a projection surface such as a screen in an enlarged scale. The projector of the embodiment is configured to be capable of projecting in a standing position in which the projector is placed on a desk or the like, and a suspending position in which the position is inverted upside down from the standing position and is installed on a ceiling or the like.

Principal Configuration of Projector

FIG. **1** is a perspective view schematically illustrating an appearance of a projector **1** of the embodiment. FIG. **2** is a diagrammatic drawing showing a schematic configuration of the projector **1** of the embodiment.

The projector **1** includes an external housing **2** constituting an exterior, a control unit (not illustrated), an optical unit **3** having a light source unit **31** and formed into a substantially L-shape in plan view, and a cooling unit **4** as illustrated in FIG. **1** and FIG. **2**. Although not illustrated in the drawing, a power supply unit configured to supply power to the light source unit **31** and the control unit is arranged in an interior of the external housing **2**. In the following description, a direction in which an optical flux goes out from the light source unit **31** is described as +X direction, a direction in which light projected from the projector **1** goes out is described as +Y direction (forward direction), and an upper side of the projector **1** in the standing position is described as +Z side for the sake of convenience of description.

The external housing **2** is formed of a synthetic resin and, as illustrated in FIG. **1**, includes an upper case **21** constituting an upper portion, a lower case **22** constituting a lower portion, and a lid member **23**.

A projection opening **211** is formed on a front surface **21**A of the upper case **21**, and a projection lens **36** provided in the optical unit **3** is arranged in the external housing **2** inside the projection opening **211**. Light emitted from the projection lens **36** passes through the projection opening **211**, and is projected on the projection surface arranged in the front.

An operation panel **20** is arranged on an upper surface **21**B of the upper case **21**. The operation panel **20** includes various keys for issuing various commands such as a menu key configured to switch display/non-display of a menu image to be used for various settings of the projector **1**, and a source switching key configured to switch an input source.

An opening **212** positioned above the light source unit **31** is formed on the upper surface **21**B of the upper case **21**, and the lid member **23** closes the opening **212**. The light source unit **31** is mounted and demounted from the opening **212** from which the lid member **23** is removed.

An intake port **213** configured to take in outside air is formed on a side surface **21**D of the upper case **21** on a +X side, and an exhaust port (which is not illustrated) configured to discharge inside air is formed in a side surface **21**C on the side opposite to the side surface **21**D. A dust-proof

filter, which is not illustrated, is arranged inside the intake port **213**, and entry of dust mixed in the outside air into the interior of the external housing **2** is suppressed.

The control unit including a CPU (Central Processing Unit), a ROM (Read Only Memory), a RAM (Random Access Memory) and the like functions as a computer, and is configured to control the operation of the projector **1**, for example, control relating to projection of images.

Configuration of Optical Unit

The optical unit **3** optically processes the light emitted from the light source unit **31** and projects the same under the control of the control unit.

The optical unit **3** includes, in addition to the light source unit **31**, an integrator lighting optical system **32**, a color separating optical system **33**, a relay optical system **34**, an electric optical unit **35**, the projection lens **36**, and an optical component housing **37** configured to arrange these optical components **31** to **36** at predetermined positions on an optical path as illustrated in FIG. **2**.

The optical unit **3** includes the light source unit **31** demountably arranged at one end portion thereof and the projection lens **36** arranged on the other end portion thereof as illustrated in FIG. **2**.

The light source unit **31** includes a discharge type light source **311** including an extra-high pressure mercury lamp or a metal halide lamp, a reflector **312**, a collimator lens **313**, a light source housing **5**.

FIG. **3** is a cross sectional view of the light source **311** and the reflector **312**.

The light source **311** includes a light-emitting tube **3111**, a pair of electrodes **3112** and **3113**, and lead wires **3114** and **3115** as illustrated in FIG. **3**.

The light-emitting tube **3111** is formed of heat-resistant glass such as quartz glass, and includes a spherical light-emitting portion **3111***a* provided at a center, and a pair of sealing portions **3111***b* and **3111***c* extending from both sides of the light-emitting portion **3111***a* as illustrated in FIG. **3**.

A discharging space in which mercury, noble gas, and halogen are sealed is formed in the light-emitting portion **3111***a*, and the pair of electrodes **3112** and **3113** are arranged in the discharging space with distal ends thereof face each other in the proximity.

A pair of metallic foils **3116** configured to be electrically connected to the electrodes **3112** and **3113** respectively are arranged in the interiors of the pair of sealing portions **3111***b* and **3111***c*.

The lead wires **3114** and **3115** are connected to the pair of metallic foils **3116** and extend to the outside of the sealing portions **3111***b* and **3111***c*. When power is supplied to the lead wires **3114** and **3115**, electric discharge occurs between the opposed electrodes **3112** and **3113**, so that the light source **311** emits light.

Here, the light source **311** generates heat by alight emission of the light-emitting tube **3111**. A temperature rise is significant in an upper portion of the light source **311** than in a lower portion thereof due to an influence of heat convection or the like and, specifically, the temperature near a surface of an upper portion of the light-emitting portion **3111***a* is liable to rise.

If the temperature of the upper portion of the light-emitting portion **3111***a* rises excessively due to insufficient cooling, a base material is recrystallized, and hence white turbidity occurs. In contrast, if the temperature of a lower portion of the light-emitting portion **3111***a* is lowered excessively due to the excessing cooling, a halogen cycle is not performed normally in the electrodes **3112** and **3113**, and hence the base material of the electrodes **3112** and **3113** is adhered to an inner wall of the light-emitting portion **3111***a*, whereby blackening may occur. If the white turbidity or the blackening occurs, the corresponding part loses its clarity, and hence light amount emitted from the light-emitting portion **3111***a* is reduced, and breakage or deterioration of the light-emitting tube **3111** may result due to a high temperature. Therefore, when cooling the light-emitting tube **3111**, it is preferable to start cooling from the upper side of the light-emitting tube **3111** to avoid generation of a temperature difference between the upper portion and the lower portion.

The temperature of the sealing portion **3111***b*, which is positioned in an area of light emitted from the light-emitting portion **3111***a*, is liable to rise and, for example, the temperature of a connecting portion between the metallic foil **3116** and the lead wire **3114** and the like rises significantly. If such portions are not sufficiently cooled, the metallic foils **3116** are oxidized and hence are blackened. Consequently, absorption of light is accelerated and hence the temperature further increases, so that the breakage or deterioration of the light-emitting tube **3111** may result. Therefore, when cooling the light source **311**, it is preferable to cool also the sealing portion **3111***b* effectively in addition to the light-emitting portion **3111***a*.

The reflector **312** has a cylindrical neck portion **3121** and a reflecting portion **3122** widening from the neck portion **3121** in a substantially concave shape in cross section as illustrated in FIG. **3**.

The neck portion **3121** is provided with an insertion hole configured to insert the sealing portion **3111***c*. The light source **311** includes the sealing portion **3111***b* positioned on a side opposite to the neck portion **3121**. An adhesive agent is injected between the sealing portion **3111***c* and the insertion hole, so that the light source **311** is fixed to the reflector **312**.

The reflecting portion **3122** includes a metal thin film deposited on an inner surface thereof so as to reflect the light emitted from the light-emitting portion **3111***a* to a direction away from the neck portion **3121**. In other words, the light source **311** is fixed to the reflector **312** so that the sealing portion **3111***b* and the lead wire **3114** are positioned in a light area reflected by the reflector **312**.

The light source unit **31** is configured to reflect the light emitted from the light source **311** by the reflector **312** and then align the direction of ejection by the collimator lens **313**, and eject the light toward the integrator lighting optical system **32**.

The light source housing **5** accommodates the light source **311** and the reflector **312**, and is provided with a plurality of flow channels which allow passage of cooling air fed from the cooling unit **4**. Components which constitute the light source unit **31** other than the light source **311**, the reflector **312**, and the collimator lens **313** will be described later in detail.

Returning back to FIG. **2**, the integrator lighting optical system **32** includes a first lens array **321**, a second lens array **322**, a polarization converter **323**, and a superimposing lens **324**, and is configured so that the light emitted from the light source unit **31** is irradiated substantially uniformly on a surface of a liquid crystal light valve **351**, which will be described later, and is used effectively.

The color separating optical system **33** includes two dichroic mirrors **331** and **332** and a reflection mirror **333**, and has a function to separate the light emitted from the integrator lighting optical system **32** into three color lights; a red light (hereinafter, referred to as "R-light"), a green light

(hereinafter, referred to as "G-light"), and a blue light (hereinafter, referred to as "B-light").

The relay optical system **34** includes an incident-side lens **341**, a relay lens **343**, and reflection mirrors **342** and **344**, and has a function to guide the R-light separated by the color separating optical system **33** to the liquid crystal light valve **351** for the R-light. The optical unit **3** has a configuration such that the relay optical system **34** guides the R-light, the invention is not limited thereto, and a configuration in which the B-light is guided is also applicable, for example.

The electric optical unit **35** includes the liquid crystal light valve **351** as a light-modulating unit and a cross-dichroic prism **352** as a color synthesizing optical device, and is configured to modulate respective color lights separated by the color separating optical system **33** in accordance with the image information, and combine the modulated color lights.

The liquid crystal light valve **351** is provided for each of the three color lights (a liquid crystal light valve for the R-light is denoted by **351**R, a liquid crystal light valve for the G-light is denoted by **351**G, and a liquid crystal light valve for the B-light is denoted by **351**B), and each includes a transmissive liquid crystal panel, and an incident side polarizing plate and an outgoing side polarizing plate arranged on both surfaces thereof.

The liquid crystal light valve **351** includes a rectangular pixel area in which minute pixels, which are not illustrated, are formed in a matrix pattern, and the respective pixels are set to a light transmissivity in accordance with display image signals, whereby a display image is formed in the pixel area. Then, the respective color lights separated by the color separating optical system **33** are modulated by the liquid crystal light valve **351**, and are emitted to the cross-dichroic prism **352**.

The cross-dichroic prism **352** is formed into a substantially square shape in plan view by bonding four rectangular prisms, and two dielectric multilayer films are formed at an interface of bonded rectangular prisms. The cross-dichroic prism **352** is configured to reflect color lights modulated by the liquid crystal light valves **351**R and **351**B from the dielectric multilayer films, and allow color light modulated by the liquid crystal light valve **351**G to pass therethrough to combine the respective color lights.

The projection lens **36** includes a plurality of lenses (which are not illustrated) and projects the light combined by the cross-dichroic prism **352** on the screen in an enlarged scale.

The cooling unit **4** includes a sirocco fan **41** arranged on the rear side (−Y direction) of the light source unit **31** and an axial flow fan **42**, and an intake fan, not illustrated arranged on the front side (+Y direction) of the light source unit **31** as illustrated in FIG. **2**.

Although detailed description will be given later, the sirocco fan **41** is configured to send the cooling air to an inflow port **831** provided in the light source housing **5** to cool the light source unit **31**.

The axial flow fan **42** is configured to discharge air in the interior of the external housing **2**, which is warmed up by cooling the light source unit **31**, through an exhaust port of the external housing **2** to the outside thereof.

The intake fan feeds cooling air on the outside taken from the intake port **213** of the upper case **21** to the electric optical unit **35**.

The power supply unit, which is not illustrated, includes a power supply block and a light source drive block configured to drive the light source unit **31**, and supplies power to the control unit and electronic components such as the light source **311**. The light source drive block includes an output connector (which is not illustrated) connected to the light source unit **31**, and the output connector is arranged in the optical component housing **37** via a cable (which is not illustrated).

Configuration of Light Source Unit

The light source unit **31** will now be described in detail.

FIG. **4** is a perspective view of the light source unit **31**.

The light source unit **31** includes an input connector **314**, connecting conductors **315** configured to supply power to the light source **311**, the light source housing **5**, a rectifying unit **6** configured to rotate to change a flow of cooling air to flow in, and conductive members **316** (see FIG. **8**) as illustrated in FIG. **4** in addition to the light source **311**, the reflector **312**, and the collimator lens **313**.

The input connector **314** is a connecting portion configured to be electrically connected to the power supply unit, and is arranged on a −Y side of the light source unit **31** as illustrated in FIG. **4**. The input connector **314** is connected to the lead wires **3114** and **3115** (see FIG. **3**) of the light source **311** via the connecting conductors **315**. The input connector **314** is connected to the output connector of the power supply unit when the light source unit **31** is inserted through the opening **212** of the upper case **21** and mounted in the optical component housing **37**. In other words, the input connector **314** is arranged to be fitted to the output connector of the power supply unit by inserting the light source unit **31** downward from above the opening **212**. Wiring of the connecting conductors **315** will be described later in detail.

The light source housing **5** includes a first housing **7** configured to accommodate the light source **311** and the reflector **312** (see FIG. **3**), a second housing **8** to be arranged on the −Y side of the first housing **7**, and a third housing **9** arranged on the −X side of the first housing **7** as illustrated in FIG. **4**. The light source housing **5** is provided with the inflow port **831** that allows entry of cooling air fed from the sirocco fan **41** and the plurality of flow channels that allow cooling air entering from the inflow port **831** to flow therethrough.

FIG. **5** and FIG. **6** are perspective views of the light source unit **31** in a state in which the second housing **8** and the third housing **9** are removed. FIG. **5** is a drawing viewed obliquely from the +X side, and FIG. **6** is a drawing viewed obliquely from the −X side. FIG. **7** is a perspective view of the first housing **7** viewed obliquely from the −X side.

The first housing **7** is formed of high heat-resistant synthetic resin and is formed into a substantially parallelepiped box shape as illustrated in FIG. **5** to FIG. **7**, and openings are provided on the +X side and the −X side. Then, the collimator lens **313** is arranged at the opening on the +X side as illustrated in FIG. **5**, and the reflector **312** to which the light source **311** is fixed is accommodated in the first housing **7** through the opening on the −X side as illustrated in FIG. **6**.

The first housing **7** includes side surfaces **71** and **76** that define the −Y side and a +Y side respectively, an upper surface **72** that defines the +Z side, and a lower surface **73** that defines a −Z side, and as illustrated in FIG. **5**, inclined surface portions **74** and **75** at corners on the −Y side.

The upper surface **72** includes a gripping portion **721** projecting in a +Z direction, a cover portion **722**, and a connecting portion **723** as illustrated in FIG. **5**.

The gripping portion **721** is opened on the +X side, and is configured to have an upright wall on the −X side, and is a portion gripped by the user together with a gripping portion **912** (see FIG. **4**), which will be described later, provided on the third housing **9**. The light source unit **31** is

mounted on and demounted from the projector **1** by the user gripping the gripping portions **721** and **912** and moving the same in the Z direction.

The cover portion **722** is formed away from the gripping portion **721** in the −X direction of the gripping portion **721**, and as illustrated in FIG. **7**, is configured to open on the −X side, and a projecting portion **7221** projecting in the −X direction is provided at a center thereof.

The cover portion **722** is provided with an upright wall **722**X on the gripping portion **721** side as illustrated in FIG. **5**, and a through hole (outflow port **722***a*) penetrating in the X direction as illustrated in FIG. **5** and FIG. **7** in the upright wall **722**X.

The first housing **7** includes a guide portion **724** also provided on the cover portion **722** and projecting from the upright wall **722**X in the −X direction as illustrated in FIG. **7**. The guide portion **724** is positioned on the +Z side of the outflow port **722***a*, and a notch **724***k* is formed in the guide portion **724** in the vicinity of the outflow port **722***a*.

The connecting portion **723** is formed so as to connect the gripping portion **721** and the cover portion **722** on the +Y side of the outflow port **722***a* as illustrated in FIG. **5**. In other words, an area **72**T having the upper surface **72** as a bottom surface and surrounded by the gripping portion **721**, the upright wall **722**X and the connecting portion **723** is provided on the +Z side of the upper surface **72**. The area **72**T defines part of a flow channel **13** branched from a flow channel **11**, described later, and cooling air flowing through the flow channel **13** flows into the first housing **7** from the outflow port **722***a*.

The inclined surface portion **74** is provided between the side surface **71** and the upper surface **72** and the inclined surface portion **74** includes a through hole (an outflow port **74***a*) as illustrated in FIG. **5**. The inclined surface portion **75** is provided between the side surface **71** and the lower surface **73** and the inclined surface portion **75** includes a through hole (an outflow port **75***a*).

The side surface **71** is provided with a bearing **711**, a pair of rotation stopper portions **712**, an inlet port **713**, and a connector mounting portion **714** as illustrated in FIG. **5**.

The bearing **711** is a circular hole in plan view having a center at a center axis extending in a direction substantially orthogonal to a perpendicular plane including an optical axis **31**L of the light source **311**, and an end of a rotating shaft (which is not illustrated), which will be described later, of the rectifying unit **6** is inserted therethrough. Then, the side surface **71** rotatably supports the rectifying unit **6** in cooperation with the second housing **8**.

The pair of rotation stopper portions **712** have a function to limit a range of rotation of the rectifying unit **6**, and the rotation stopper portions **712** are provided so as to project outward of the side surface **71**. The pair of rotation stopper portions **712** are positioned close to each other on the bearing **711** side, and are inclined so as to extend away from each other as they go toward the bearing **711** in the +X direction.

The inlet port **713** is a through hole configured to introduce part of cooling air flowing inward from the inflow port **831** into an interior of the first housing **7**, and as illustrated in FIG. **5**, is formed so as to be positioned between the pair of rotation stopper portions **712** in the +X direction of the bearing **711**.

The connector mounting portion **714** is formed on the −X side of the bearing **711**, and includes an upright wall **7141** projecting in the −Y direction and an upright wall **7142** projecting in the −X direction as illustrated in FIG. **5**.

The upright wall **7141** is provided on the +Z side with a projecting portion **7143** projecting further in the +Z direction, and on the −Z side with an engaging portion **7144**. The upright wall **7142** is provided with a U-groove **7145** having a U-shape in cross section on a −X side end surface on the +Z side, and with an engaging portion **7146** at a position opposing the engaging portion **7144** on the −Z side. The input connector **314** is arranged in a state of being engaged with the engaging portions **7144** and **7146** as illustrated in FIG. **5** and FIG. **6**.

The side surface **76** is provided with an exhaust port **761** from which air in the first housing **7** is discharged to the outside as illustrated in FIG. **7**.

The second housing **8** is fixed to the −Y side of the first housing **7** with a screw, and defines the plurality of flow channels in cooperation with the first housing **7** as illustrated in FIG. **4**.

The second housing **8** is formed into a box shape opening on the +Y side, and includes a first protruding portion **81** configured to cover the inclined surface portion **74** of the first housing **7** and the +Z side (see FIG. **5**) of the area **72**T, a second protruding portion **82** configured to cover the inclined surface portion **75** (see FIG. **5**), and a housing center portion **83** configured to cover the side surface **71** (see FIG. **5**) between the inclined surface portion **74** and the inclined surface portion **75**.

A wall portion on the +X side of the housing center portion **83** includes the inflow port **831**. The inflow port **831** is formed into a rectangular shape in plan view and allows entry of a flow of cooling air fed from the sirocco fan **41** (see FIG. **2**). A mesh-type member, which is not illustrated, is fitted in the inflow port **831** and the exhaust port **761** of the first housing **7** to prevent broken pieces from flying outward around in case of breakage of the light-emitting tube **3111**.

The first protruding portion **81** defines the flow channels **11** and **13** in cooperation with the first housing **7**. The flow channel **11** guides cooling air entering from the inflow port **831**, and the guided cooling air flows out from the outflow port **74***a* of the first housing **7** into the first housing **7**.

The flow channel **13** is formed so as to be branched from the flow channel **11** and guides part of cooling air entering from the inflow port **831**, and the guided cooling air flows out from the outflow port **722***a* of the first housing **7** into the first housing **7**.

The second protruding portion **82** defines a flow channel **12** in cooperation with the first housing **7**. The flow channel **12** introduces cooling air entering from the inflow port **831**, and the introduced cooling air flows out from the outflow port **75***a* of the first housing **7** into the first housing **7**.

A bearing and rotation stopper portions, which are not illustrated, are provided in an inner surface of the housing center portion **83**.

The bearing of the housing center portion **83** is provided at a position opposing the bearing **711** (see FIG. **5**) of the first housing **7**, and the other end of the rotating shaft, described later, of the rectifying unit **6** is inserted thereto. The second housing **8** rotatably supports the rectifying unit **6** in cooperation with the first housing **7** as described above.

The pair of rotation stopper portions of the second housing **8** are provided at positions opposing the pair of rotation stopper portions **712** of the first housing **7**, and are configured to limit the range of rotation of the rectifying unit **6** in the same manner as the rotation stopper portions **712**.

The third housing **9** is formed of a high heat-resistant synthetic resin, and formed into a box shape having an opening on the +X side, and is configured to cover the −X

side of the reflector **312** by being combined with the first housing **7** on the −X side as illustrated in FIG. **4**.

The third housing **9** includes an upper surface **91** that defines the +Z side, a lower surface **92** that defines the −Z side, and side surfaces **93** and **94** that define the −Y side and the +Y side, and a back surface **95** that defines the −X side as illustrated in FIG. **4**.

The upper surface **91** includes a cover portion **911** and the gripping portion **912** projecting in the +Z direction.

The cover portion **911** is formed so as to be connected to the cover portion **722** of the first housing **7**, and the center portion is formed so as to be depressed to fit to the projecting portion **7221** of the cover portion **722** of the first housing **7**.

The gripping portion **912** is formed so as to be connected to a −X side of the cover portion **911**. The gripping portion **912** is opened on the −X side and is formed so as to have an upright wall between the gripping portion **912** and the cover portion **911**. The gripping portion **912** is gripped by the user together with the gripping portion **721** of the first housing **7** when the light source unit **31** is demounted and mounted as described above.

The third housing **9** includes a protruding portion **96** positioned in the +Z direction of the input connector **314** and connected to the upper surface **91** and the side surface **93** as illustrated in FIG. **4**.

The protruding portion **96** is positioned on the −Y side of the cover portion **722**, and is formed to have a size enough to cover the +Z side and the −Y side of the projecting portion **7143**, and the connecting conductors **315** in the vicinity of the input connector **314**.

The third housing **9** is fixed to the first housing **7** by screws inserted into holes, which are not illustrated, provided at four corners.

FIG. **8** is a cross-sectional view of the light source unit **31** and the lid member **23**.

The conductive members **316** include a first light-shielding member **3161** arranged in the first housing **7**, a second light-shielding member **3162** arranged in the third housing **9** as illustrated in FIG. **8**, and a fixing member **3163** arranged on the −X side of the reflector **312** as illustrated in FIG. **6**.

The first light-shielding member **3161** is formed of a metal plate and is formed so as to cover the +X side in the first housing **7**.

The second light-shielding member **3162** is formed of a metal plate and is formed so as to cover in the third housing **9**.

The first light-shielding member **3161** and the second light-shielding member **3162** are formed so as to suppress the first housing **7** and the third housing **9** from directly being irradiated with light emitted from the light source **311**. The first light-shielding member **3161** and the second light-shielding member **3162** suppress deterioration of the first housing **7** and the third housing **9** due to light.

The fixing member **3163** includes a plurality of spring members **3163***a* configured to urge an edge portion of the reflector **312**, and has a function to fix the reflector **312** on which the light source **311** is fixed in the light source housing **5** in cooperation with the third housing **9** as illustrated in FIG. **6**.

The fixing member **3163** is pressed by the third housing **9** when the third housing **9** is fixed to the first housing **7** with screws, and the spring members **3163***a* urge the reflector **312**. Consequently, the reflector **312** on which the light source **311** is fixed is fixed in the light source housing **5**.

Here, the connecting conductors **315** will be described. The connecting conductors **315** include a first connecting conductor **315***a* to be connected to the lead wire **3114** and a second connecting conductor **315***b* to be connected to the lead wire **3115**, and each connecting conductor is connected to the input connector **314** as illustrated in FIG. **8**.

The first connecting conductor **315***a* extends from the lead wire **3114** in the +Z direction as illustrated in FIG. **8**, passes through the notch **724***k* as illustrated in FIG. **6**, is bent in the −Y direction, is arranged between the cover portion **722** and the guide portion **724**, and is connected to the input connector **314** positioned on the −Y side of the upright wall **7142**. The first connecting conductor **315***a* is covered with an insulating member from the vicinity of the notch **724***k* between the cover portion **722** and the guide portion **724** to the input connector **314** and is laid so as to be restricted from projecting out in the −Y direction by the projecting portion **7143**. In this manner, the first connecting conductor **315***a* is laid so that a portion passing through the notch **724***k* is arranged in the first housing **7** of the outflow port **722***a*, that is, at a position where cooling air flowed from the outflow port **722***a* passes, and portion covered with the insulating member is positioned by the cover portion **722** and the guide portion **724**.

The second connecting conductor **315***b* extends from the lead wire **3115** in the +Z direction as illustrated in FIG. **8**, and is passed through the U-groove **7145** of the first housing **7** and is connected to the input connector **314** as illustrated in FIG. **5**. The second connecting conductor **315***b* is covered with the insulating member from the vicinity of the lead wire **3115** to the input connector **314**, and is passed through the U-groove **7145**, so that projecting out in the +Z direction and the −Y direction is restricted.

The third housing **9** is fixed to the first housing **7** with screws after the first connecting conductor **315***a* and the second connecting conductor **315***b* have been wired as described above.

In a state in which the third housing **9** is fixed to the first housing **7**, the first connecting conductor **315***a* and the second connecting conductor **315***b* are accommodated in the first housing **7** and the third housing **9**, and are covered with the light source housing **5** on the +Z side, that is, on the lid member **23** side as illustrated in FIG. **4**.

In this manner, the upper surface **72** and the cover portion **722** of the first housing **7**, the first protruding portion **81** of the second housing **8**, the upper surface **91**, the cover portion **911**, and the protruding portion **96** of the third housing **9**, that define the lid member **23** side of the light source housing **5** cover the lid member **23** side of the light source **311**, the connecting conductors **315**, and the conductive members **316** and correspond to lid-side forming portions. The cover portions **722** and **911** form part of the lid-side forming portions.

The rectifying unit **6** is configured to rotate in accordance with the standing position and the suspending position of the projector **1**, branch cooling air entering from the inflow port **831**, and change the amount of the cooling air to be flowed to the flow channels **11** and **12** provided in the light source housing **5**.

The rectifying unit **6** is formed of a metal plate, and includes a rectifying unit body **61** having a trapezoidal shape in plan view, and a rotating shaft (which is not illustrated) provided on the side of the short side of the rectifying unit body **61** as illustrated in FIG. **4**, although detailed illustration is omitted. The rectifying unit body **61** includes a notched opening **62** at an end thereof on the side of the long side, which is a side opposite from the rotating shaft.

The rectifying unit **6** is supported at the rotating shaft thereof by the first housing **7** and the second housing **8**, and rotates under its own weight.

Flow of Cooling Air

Now, a flow of cooling air fed from the sirocco fan **41** will be described.

First of all, a flow of cooling air in the case where the projector **1** is placed in the standing position will be described.

When the projector **1** is in the standing position, the rectifying unit **6** comes into abutment with the rotation stopper portions **712** (see FIG. **5**) of the first housing **7** and the rotation stopper portion of the second housing **8** under its own weight, and the end opposite from the rotating shaft is positioned on the −Z direction of the inlet port **713** as illustrated in FIG. **4**.

A large part of cooling air **100** fed from the sirocco fan **41** and enters from the inflow port **831** hits against the rectifying unit **6**, and is branched into cooling air **101** flowing in the flow channel **11** and cooling air **102** flowing toward the inlet port **713**, and part of the cooling air **100** flows from the opening **62** of the rectifying unit **6** to the flow channel **12** (cooling air **103**) as illustrated in FIG. **5**.

The cooling air **101** flowing through the flow channel **11** is branched to cooling air **1011** guided to the outflow port **74***a* of the first housing **7** and cooling air **1012** flowing through the flow channel **13** and guided to the outflow port **722***a* as illustrated in FIG. **5** and FIG. **7**. The cooling air **1011** flowed out from the outflow port **74***a* cools mainly the upper portion of the light source **311**, specifically, the upper portion of the light-emitting portion **3111***a*, and the cooling air **1012** flowed out from the outflow port **722***a* mainly cools the cover portions **722** and **911**. In this manner, the flow channel **11** corresponds to a main flow channel in which the cooling air to the light source **311** passes, and the flow channel **13** guides part of the cooling air flowing through the flow channel **11** as the main flow channel to the outflow port **722***a*.

The cooling air **102** entering from the inlet port **713** cools from the side of the light source **311** to the sealing portion **3111***b* (see FIG. **3**).

The cooling air **103** passing through the flow channel **12** flows out from the outflow port **75***a* of the first housing **7**, and cools the lower portion of the light source **311**.

Then, the air that has cooled the object to be cooled by flowing through the flow channels **11** and **12**, and the inlet port **713** is discharged to the outside of the external housing **2** by the axial flow fan **42** via the exhaust port **761** of the first housing **7**.

Subsequently, a case where the projector **1** is in the suspending position will be described.

When the projector **1** is changed from the standing position to the suspending position, although illustration is omitted, the rectifying unit **6** rotates under its own weight and comes into abutment with the rotation stopper portions **712** (see FIG. **5**) of the first housing **7**, and the rotation stopper portion of the second housing **8**, and the end of the rectifying unit **6** opposite to the rotating shaft is positioned at a position in the +Z direction of the inlet port **713**.

A large part of cooling air fed from the sirocco fan **41** and enters from the inflow port **831** hits against the rectifying unit **6** and is branched into cooling air flowing toward the flow channel **12**, and cooling air flowing toward the inlet port **713**, and part of the cooling air flows from the opening **62** of the rectifying unit **6** to the flow channel **11**.

The cooling air passing through the flow channel **12** flows from the outflow port **75***a* of the first housing **7**, and cools mainly the upper portion of the light source **311**, specifically the upper portion of the light-emitting portion **3111***a*.

In the same manner as the case of the standing position, the cooling air entering from the inlet port **713** cools from the side of the light source **311** to a portion of the sealing portion **3111***b* (see FIG. **3**) in the vicinity of the distal end portion thereof.

The cooling air passing through the flow channel **11** flows from the outflow ports **74***a* and **722***a* of the first housing **7**. The cooling air flowed out from the outflow port **74***a* cools mainly the lower portion of the light source **311**, and the cooling air flowed out from the outflow port **722***a* mainly cools the cover portions **722** and **911**.

In this manner, when the projector **1** is positioned in the standing position and in the suspending position, the flow channels **11** and **12** guide a larger amount of cooling air to the upper portion of the light source **311** than to the lower portion thereof and the flow channel **11** guides cooling air to the cover portions **722** and **911**, that is, to at least part of the lid-side forming portions.

As described thus far, according to the embodiment, the following effects are achieved.

(1) Since the light source housing **5** has the lid-side forming portions, the user is prevented from touching or coming close to the light source **311**, the connecting conductors **315**, and the conductive members **316** arranged in the light source housing **5** when replacing the light source unit **31**.

The light source housing **5** is provided with the flow channel **13** configured to guide the cooling air to the cover portions **722** and **911** that define part of the lid-side forming portions, the cover portions **722** and **911** that are increased in temperature may be cooled down by covering the lid member **23** side of the light source **311**. In particular, when the projector **1** is in the standing position in which the lid member **23** is positioned above the light source unit **31**, the lid-side forming portions are positioned above the light source **311**, so that more remarkable advantages are achieved.

Therefore, the light source **311**, the connecting conductors **315**, and the conductive members **316** are reliably kept away from the user when the user mounts and demounts the light source unit **31**, whereby the deterioration of the light source housing **5** due to the temperature may be suppressed while enhancing wiring flexibility of the connecting conductors **315** and the flexibility in shape of the conductive members **316**. Therefore, the projector **1** provided with the light source unit **31** which has a longer lifetime while achieving easiness of manufacture and improvement of design flexibility is provided.

(2) The first housing **7** and the second housing **8** are combined, and hence the inflow port **831** and the flow channels **11** and **13** are easily formed, and part of the cooling air **101** entering from the inflow port **831** flows out from the outflow port **722***a* and is fed to the cover portions **722** and **911**. Therefore, a configuration of feeding the cooling air to at least part of the lid-side forming portions is achieved with a simple structure.

The flow channel **13** is also formed so as to be branched from the flow channel **11** as a main flow channel. Accordingly, since an area through which the cooling air is caused to flow may be increased in comparison with a case where the flow channel **11** as the main flow channel and the flow channel **13** are formed individually, efficient cooling of the object to be cooled is achieved.

(3) The first connecting conductor **315***a* to be connected to the lead wire **3114**, being partly arranged in the outflow port **722***a* in the interior of the first housing **7**, is cooled by

the cooling air fed to the lid-side forming portions. Therefore, effective cooling of the light source unit **31** is enabled.

(4) The light source housing **5** includes the guide portion **724** configured to position the first connecting conductor **315***a* in cooperation with the cover portion **722**. Therefore, the first connecting conductor **315***a* is reliably laid at a predetermined position on the lid member **23** side of the light source **311**. Therefore, further stable cooling of the first connecting conductor **315***a* by the cooling air **1012** fed to the lid-side forming portions and reduction of the load applied to the first connecting conductor **315***a* during the step of manufacturing the light source unit **31** and when handling the light source unit **31** are achieved.

(5) Since the light source unit **31** is provided with the above described flow channels **11** and **12**, and the rectifying unit **6** having the opening **62**, a larger amount of cooling air is guided to the upper portion of the light source **311** than to the lower portion, so that well balanced cooling of the upper portion and the lower portion of the light source **311** is achieved, and also the cover portions **722** and **911** may be cooled in the standing position and the suspending position. The cooling air guided to the cover portions **722** and **911** is smaller in amount in the suspending position than in the case of the standing position. However, in the suspending position, the cover portions **722** and **911** are positioned below the light source **311**, and hence temperature increase is not much. Therefore, cooling is achieved with a small amount of cooling air.

Modification

The embodiment described above may be modified as described below.

The projector **1** of the above described embodiment is formed so that the light source unit **31** is mounted and demounted from above in the standing position. However, the projector may be configured in such a manner that the light source unit **31** is mounted and demounted from below in the standing position. In this case as well, the light source housing is configured to have lid-side forming portions that cover the light source and the gripping portion side of the connecting conductor and the flow channel configured to guide the cooling air to at least part of the lid-side forming portions, so that the same advantages as the projector **1** of the embodiment is achieved in the suspending position and the standing position.

The configuration in which the light source housing has lid-side forming portions that cover the light source and the gripping portion side of the connecting conductor and the flow channel configured to guide the cooling air to at least part of the lid-side forming portions may be applied to the light source unit that is not provided with the rectifying unit **6**.

Although the projector **1** in the embodiment described above employs the transmissive liquid crystal panel as the light-modulating unit, a reflective liquid crystal panel may also be employed. The light-modulating unit may employ a micro mirror display device.

The light-modulating unit of the embodiments described above employs a so-called three-panel system, in which three light-modulating units corresponding to R-light, G-light, and B-light are used. Instead, however, a single plate system may also be employed. Alternatively, the light-modulating unit of the embodiments described above may also be applied to a projector including two, four or more of the light-modulating units.

The light source unit is not limited to that having a discharging type light source, and lamps of other types or solid light sources such as light-emitting diodes may be employed as long as the light source unit is configured to be mountable and demountable by the user.

What is claimed is:

1. A light source unit comprising:

a light source;

a connecting conductor configured to supply power to the light source;

a light source housing configured to accommodate the light source and the connecting conductor, and including a gripping portion;

a main flow channel configured to allow the cooling air to flow to the light source; and

a reflector configured to reflect light emitted from the light source,

wherein the light source housing includes:

a lid-side forming portion configured to cover the light source and the gripping portion side of the connecting conductor and including a cover portion configured to project in a same direction of the gripping portion,

an outflow port configured to allow the cooling air to go out toward the lid-side forming portion, and

a flow channel configured to guide a part of cooling air flowing through the main flow channel to the outflow port, and

wherein;

the cooling air flowed out from the outflow port mainly cools the cover portion,

the light source includes a light-emitting tube having a pair of electrodes and a pair of lead wires configured to be electrically connected to the pair of electrodes, respectively,

one of the pair of lead wires is arranged on a side of the reflector where the light is reflected,

the connecting conductor includes a first connecting conductor to be connected to the one of the lead wires and a second connecting conductor to be connected to the other lead wire, and

part of the first connecting conductor is arranged at the position where the cooling air flowing out from the outflow port of the light source housing passes.

2. The light source unit according to claim **1**, wherein

the light source housing includes a guide portion configured to position the connecting conductor in cooperation with the lid-side forming portion.

3. A projector comprising:

the light source unit according to claim **1**;

an external housing configured to accommodate the light source unit and having an opening through which the light source unit is mounted and demounted; and

a lid member configured to close the opening.

4. The projector according to claim **3**, wherein

the light source unit includes a reflector configured to reflect light emitted from the light source,

the light source includes a light-emitting tube having a pair of electrodes and a pair of lead wires configured to be electrically connected to the pair of electrodes, respectively,

one of the pair of lead wires is arranged on a side of the reflector where the light is reflected,

the connecting conductor includes a first connecting conductor to be connected to the one of the lead wires and a second connecting conductor to be connected to the other lead wire, and

part of the first connecting conductor is arranged at the position where the cooling air flowing out from the outflow port of the light source housing passes.

5. The projector according to claim 3, wherein
the light source housing includes a guide portion configured to position the connecting conductor in cooperation with the lid-side forming portion.

6. The light source unit according to claim 1, wherein
the reflector has a reflective surface configured to reflect light emitted from the light source, and
the outflow port is configured to guide cooling air to a rear surface of the reflector opposite the reflective surface.

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